How to Improve UrQMD Model to Describe NA61/SHINE Experimental Data

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The NA61/SHINE collaboration measured inclusive cross sections of π^+ and π^- meson production in the interactions of 31 GeV/c proton with carbon nuclei at small emission angles (0 – 420 *mrad*). The collaboration presented also predictions of Monte Carlo models – FLUKA, VENUS and UrQMD, in a comparison with the data. The worst description of the data was observed for UrQMD model results.

In the present paper it is shown that the drawback of the UrQMD model is connected with an inaccurate treatment of low mass string fragmentation. The strings appeared at a diffraction of target nucleons. A simple patch is proposed to overcome the problem.

The discrepancy saying above between the NA61/SHINE data and UrQMD model predictions is shown in Fig. 1. As seen, the model overestimates the experimental data for low momenta ($p < 1.5$ *GeV/c*) very strongly. Because the excess is observed for low energy mesons, it can be supposed that a mistake is connected with a particle cascading inside the nucleus, or with the low mass diffraction of the target nucleons.

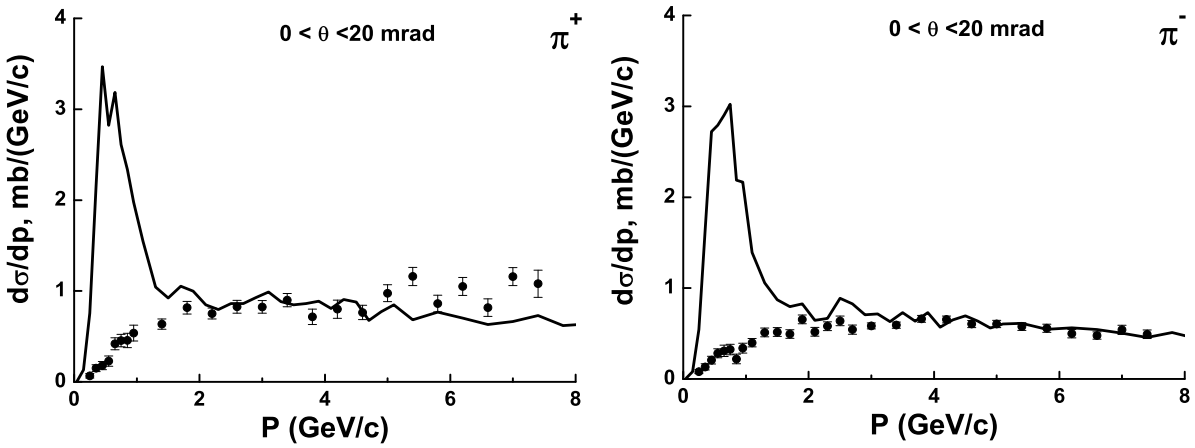

Figure 1: Inclusive cross sections of meson production at $\theta = 0$ – 20 *mrad*. Points are experimental data [1]. Lines are the UrQMD model 1.3 [2] predictions.

It was checked that a change of the cascade parameters does not affect on the predicted meson spectra. The following calculations have been done:

1. The parameter *XAP* - string tension, in the file *string.f* of the UrQMD 1.3 code was changed from 1 to 0.1 (*fm/GeV*) in order to increase the particle formation time. One line was added in *subroutine leadhad* in the file *scatter.f* to switch out the leading particle effect.

```
      subroutine leadhad(n1l,n2l,nbl)
      implicit none
      include 'newpart.inc'
      include 'comres.inc'
      include 'coms.inc'
      integer n1l,n2l,nbl,ll

c default: no leading hadron at all
       do 1 ll=n1l,n2l
```

```
         leadfac(ll)=0.d0
1    continue
     Return                      ! Uzhi
```

2. The average transverse momentum, P_T = 1.6 (GeV/c), transferred between interacting nucleons was changed to 0.4 (GeV/c) (*CTParam(31)=0.4*, see "User Guide") to increase produced particles momenta.

3. The parameter *Beta* was put to zero (*CTParam(40)=0*) to change string mass distribution.

4. *CTParam(2)* was put to 0.26 in order to decrease the single diffraction probability.

All was vain!

An analysis of a simulation of the single diffraction in NN-interactions shows that most of the created strings have low masses, $\sim$ 1.3 - 1.6 (GeV). Thus, instead of a fragmentation, a two-particles decay of a string is simulated in the *SUBROUTINE CLUSTR* (see the file *string.f*) where the following lines are:

```
c..forward/backward distribution in clustr for baryons
c..(no pt in the last string break!)
c..pt for the baryon comes from parton kick in the excitation
      if(abs(ident(i)).ge.1000.or.abs(ident(i-1)).ge.1000)then
      PPTCL(1,I-1)=0.d0
      PPTCL(1,I)=0.d0
      PPTCL(2,I-1)=0.d0
      PPTCL(2,I)=0.d0
      PPTCL(3,I-1)=PA
      PPTCL(3,I)=-PA
      PA2=PA**2
      PPTCL(4,I-1)=SQRT(PA2+PPTCL(5,I-1)**2)
      PPTCL(4,I)=SQRT(PA2+PPTCL(5,I)**2)
      IDCAY(I-1)=0
      IDCAY(I)=0
      NPTCL=I
      endif
```

As a result, the produced mesons have zero P_T, and they fill the region of small p in Fig. 1.

There is a part for a simulation of the isotropic two-particle decay just before the lines. Thus, it is very easy to improve the UrQMD code closing the presented lines :

```
c..forward/backward distribution in clustr for baryons
c..(no pt in the last string break!)
c..pt for the baryon comes from parton kick in the excitation
cUzhi if(abs(ident(i)).ge.1000.or.abs(ident(i-1)).ge.1000)then
cUzhi PPTCL(1,I-1)=0.d0
cUzhi PPTCL(1,I)=0.d0
cUzhi PPTCL(2,I-1)=0.d0
cUzhi PPTCL(2,I)=0.d0
cUzhi PPTCL(3,I-1)=PA
cUzhi PPTCL(3,I)=-PA
cUzhi PA2=PA**2
cUzhi PPTCL(4,I-1)=SQRT(PA2+PPTCL(5,I-1)**2)
cUzhi PPTCL(4,I)=SQRT(PA2+PPTCL(5,I)**2)
cUzhi IDCAY(I-1)=0
cUzhi IDCAY(I)=0
cUzhi NPTCL=I
cUzhi endif
```

The calculation results obtained with the proposed changes are shown in Fig. 2.

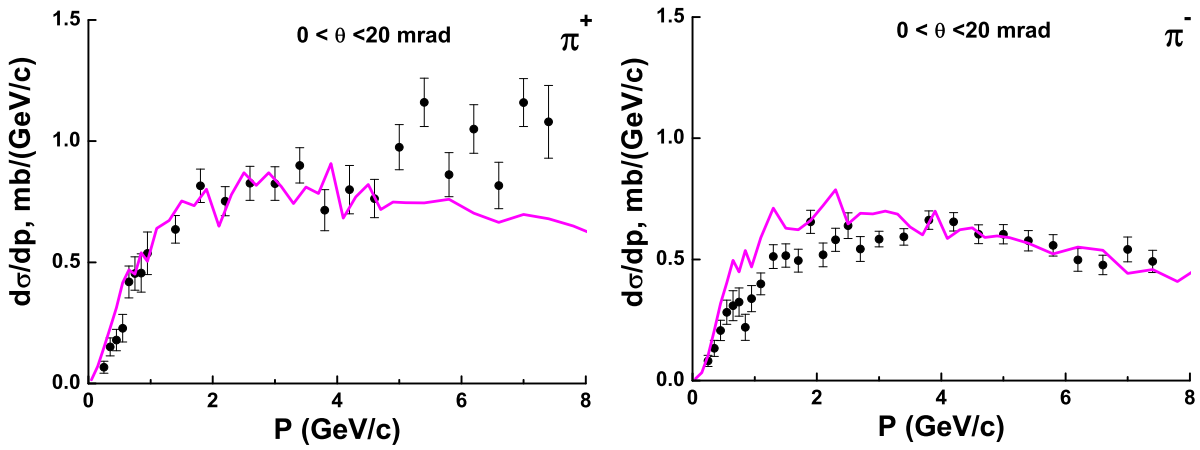

Figure 2: Inclusive cross sections of meson production at $\theta = 0 - 20$ *mrad*. Points are experimental data [1]. Lines are the bug fixed UrQMD model predictions.

The author is thankful to G. Folger and V. Ivanchenko for interest to the work and important remarks.

References

[1] NA61/SHINE Collaboration (N. Abgrall et al.)// Arxiv::hep-ex 1102.0983.

[2] S.A. Bass et al.// Prog. Part. Nucl. Phys. 41, 225 (1998); M. Bleicher et al.// J. Phys. G 25, 1859 (1999).